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ABSTRACT

Sixty-three studies which investigated cognitive achievement effects following interactive video (IV) instruction were integrated through a meta-analysis technique. Overall, mean achievement effect for IV was .530 (corrected for outliers), indicating that IV is an effective form of instruction. The effect is similar to that of computer-assisted instruction. A test of homogeneity on effect sizes revealed that they were not homogeneous. Failure to account for more variance in the models by independent variables analyzed in this study indicates that cognitive achievement from IV is influenced by a myriad of variables (including the nature of the instructional content, environmental factors, instructional methods, features of the learning materials, and characteristics of the learner) that are difficult or impossible to account for in a single meta-analysis. Results revealed that differences in program effectiveness favoring group instruction may be explained by factors such as decisions made by the teacher relative to the amount of practice, the extent and kind of feedback, and the nature of remediation procedures. Moreover, program-controlled IV appeared to be more effective than learner-controlled IV. The 63 studies included in the analysis are cited, and data are presented in six tables. (41 references) (Author/GL)

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# Meta-Analysis of Interactive Video Instruction: A 10 Year Review of Achievement Effects

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Abstract

Sixty-three studies which investigated cognitive achievement effects following interactive video (IV) instruction were integrated through a meta-analysis technique. Overall, mean achievement effect for IV was .530 (corrected for outliers) indicating that IV is an effective form of instruction. The effect is similar to that of computer-assisted instruction.

Test of homogeneity on effect sizes (ES) revealed that ES's were not homogeneous. Failure to account for more variance in the models by independent variables analyzed in this study indicates that cognitive achievement from IV is influenced by a myriad of variables that are difficult or impossible to account for in a single meta-analysis.

Results revealed that differences in program effectiveness favoring group instruction may be explained by factors such as decisions made by the teacher relative to amount of practice, the extent and kind of feedback and the nature of remediation procedures. Moreover, program controlled IV appeared to be more effective than learner-controlled IV.

# Meta-Analysis of Interactive Video Instruction: A 10 Year Review of Achievement Effects

Today's information and technology explosion has caused an increasingly acute need to bolster training efforts in labor-intensive sectors such as private industry, the military, and educational institutions. Many teachers, business leaders, and administrators are enthusiastically investing in interactive video (IV) instruction as a solution to spiraling training costs and limitations in instructional time and personnel.

Typically, IV incorporates the interactivity and control of a computer with the audio-visual capabilities of videotape, videodisc, or television. This medium has the potential for being unique and greater than the sum of its parts (Brody, 1984). With the computer controlling for the presentation of color, sound, still images, text, and motion video sequences, IV has the capability of presenting realistic visual depictions of the problem situation. The learner is provided with extensive feedback during the learning situation, facilitating an experience with "real life" situations and consequences.

Educators such as Price and Marsh II (1983) have projected that IV will potentially "transform the educational delivery

system in public education " (p. 112). At the same time, many decision-makers, predominantly in the field of education, are reticent about embracing IV. They are faced with extravagant claims made by IV advocates as well as warnings by researchers to proceed cautiously before adopting this instructional innovation. Fiscal constraints imposed upon education further complicate this situation and mandate that decision-makers justify substantial investments in instructional technology.

A logical first step in the quest for evidence documenting the effectiveness of IV instruction involves an examination of the research literature. It is here that evaluators encounter the controversy surrounding IV. The literature on IV is vast and interdisciplinary in nature. It encompasses evaluative studies comparing IV to other forms of instruction, anecdotal reports documenting development and use of specific IV programs, and investigations of instructional design features. Subject matter for IV programs is diverse, including, for example, teaching of cancer chemotherapy (Fishman, 1983), Spanish language instruction (Verano, 1987), leadership skills (Schroeder, Dyer, Czerney, Youngling-Gillotti, 1986a), and health behavior training (Kimbrough, 1982). Findings of evaluations comparing IV to other forms of instruction have varied from no significant differences

on initial tests of achievement (eg., Ebner, et al., 1984) to significantly higher achievement test scores for IV instruction (eg., Abrams, 1986; Boen, 1985; Crotty, 1984; Fishman, 1983; Verano, 1987). A review of the IV literature over a span of 10 years has resulted in five traditional reviews of the effectiveness of IV (Bosco, 1986; DeBloois, 1988; Debloois, Maki, & Hall, 1984; Manning, Ebner, Brooks, & Balson, 1983; Smith, 1987). At best, conclusions from reports are generally positive yet cite inconsistent and contradictory findings. Some authors contend that little empirical research has been published to either support the effects on learning, the comparative effectiveness, or even the validation of the basic assumptions of interactive video (Hannafin, 1985). Kearsley and Frost (1985) reported that a large amount of evidence exists which strongly supports the effectiveness of IV for teaching and learning. Hiscox (1982) reports that the growth of enthusiasm for IV is based on "large numbers of glowing, oversimplified articles" which have been widely distributed in the media. He proposes that this enthusiasm is an "unrealistic expectation of what is truly involved in implementing videodisc-based instruction" (p. 103).

Leading IV researchers have responded to the call for change in IV research by proposing agendas for additional research on and

with interactive video (Bosco, 1986; Brody, 1984; Cushall, Harvey, & Brovey, 1987; Evans, 1986; Hannafin, 1985; Reeves, 1986; Smith, 1987). Reeves (1986) has proposed alternative paradigms for IV research. Brody (1984) suggests thoroughly and systematically analyzing the potential of IV. Hannafin (1985) proposes a framework for the empirical study of computer-assisted interactive video. A number of IV leaders are recommending that the focus of IV research move beyond comparative studies and concentrate of IV features that maximize learning effectiveness.

Hannafin (1985) postulates that researchers may not be clear about where to initiate studies of IV. The direction of research efforts and recommendations for further research and evaluation of IV were discussed at the National Conference on Postsecondary Utilization of Videodisc (February, 1988). One recommendation by this group provides direction for researchers as well as support for the present study:

> ....there needs to be a focus on meta evaluations that look across many studies that have been done, and the many interrelated variables within a medium as rich as videodisc. ....such a meta evaluation approach could provide broad new insight for videodisc developers and better relate videodisc to other new educational technologies. (p. 36)

The need for a quantitative review of the literature of IV is vital to an understanding of the nature and effectiveness of IV instruction. A systematic research synthesis of the effectiveness of IV may provide a clear understanding of ingredients for maximizing IV instruction. Although several researchers have published meta-analyses of the effectiveness of computer-assisted instruction (Hartley, 1977; Kulik, Bangert, & Williams, 1983; Kulik, Kulik, & Cohen, 1979; Niemiec & Walberg, 1987), no meta analysis of the effectiveness of IV learning has been conducted.

This study quantitatively examined the effectiveness of IV instruction by employing a meta-analytic research review of literature from 1978 to the present. It was also a purpose of this study to provide a quantitative analysis of the specific instructional design features associated with positive learning outcomes.

## Method

### Selection of the Data

Data for the meta-analysis were from studies which reported learning outcomes from IV instruction. According to Floyd and Floyd (1982), IV is defined as a video program in which the sequence and selection of content is determined by the learner's response. This study also incorporated the levels of

interactivity shown in Table 1. The classification system was proposed by the Nebraska Videodisc Design and Production Group and later augmented (Hofmeister, Engelmann, & Carnine, 1986). Learning outcomes were delimited to include cognitive and performance acquisition and retention achievement measures such as post tests.

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Insert Table 1 About Here

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Glass was one of the first to propose a meta-analytic approach for integrating research findings (Hedges, 1981). There are five steps in conducting a meta-analysis: (1) specifying inclusion criteria, (2) locating studies, (3) coding study features, (4) calculating individual outcomes, (5) data analysis. Each step will be briefly described.

Inclusion Criteria. First, studies were included which reported achievement outcomes involving performance and cognitive measures for an interactive video group and a control or comparison group. The researchers excluded studies which exclusively investigated attitudinal effects, time efficiency, or cost effectiveness. Second, the analysis included experimental and quasi-experimental studies and excluded anecdotal reports.

Third, studies were included which operationalized IV according to the definition set forth by Floyd and Floyd (1982) and which fit one of the levels (1 to 4) of interactivity cited by Hofmeister et al. (1986) which is shown in Table 1. Fourth, studies which contained obvious methodological flaws such as small sample size and high subject mortality were excluded. Lastly, if minimal data to compute effect size (such as means, standard deviations, t test, F values) were lacking, the study was excluded.

Locating Studies. The second step in this meta-analysis was to locate studies dated from 1978 through 1988. The year 1978 was selected since it marked the approximate year that videodiscs and systems were first marketed in the United States (Gindele & Gindele, 1984).

A literature search was conducted using five data bases: Educational Resources Information Center (ERIC), Dissertations Abstracts International (DAI), National Technical Information Service (NTIS), MEDLINE, and Government Printing Office (GPO). The bibliographic searches yielded over 300 titles, many of which were duplicate studies. After examining information in the abstracts and titles, 190 studies failed to meet the criteria set for the analysis. The remaining 110 studies were obtained and read. To further extend the search, bibliographies of these

studies were examined as a secondary source of data.

Several journals and proceedings from 1978 through November, 1988 were searched by hand (these are listed at the end of this article). From this search of journals and bulletins, 65 authors or corporations were identified who had potentially useful studies. In order to secure these studies, letters were mailed to the authors/corporations requesting a copy of the report and informing the party of the intent to conduct a meta-analysis. Contact was made with major corporations, journal editors, branches of the military, and major educational technology researchers who were active in interactive video development. The majority of studies obtained through this correspondence were anecdotal in nature. However, making contact with some individuals was fruitful. They sent more than one useful study or referred the researcher to other contacts. From this search, a total of 67 studies were obtained but only 23 could be included in the meta-analysis. Out of an overall total of 367 studies which were identified for initial consideration, 63 (see Table 2) met the criteria for inclusion in this meta-analysis.

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Insert Table 2 About Here

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Coding. The third step in a meta-analysis is to determine which variables are to be coded from each study. Before any of the studies were read, descriptive variables were identified. These included name of author, date of publication, subject of instruction, independent/dependent variables, type of comparison group, and findings of the study. After reading several studies, the first draft of the code sheet was created. The intent was to initially code as much data as possible and then to select variables of interest. As more studies were read, variables were added and refined resulting in a final version of the coding sheet in which four major categories of variables were defined: characteristics of the study (such as year of publication and type of manuscript); dependent variable factors which included type of task for the achievement measure; instructional design features such as interactivity level and degree of learner control of sequence of instruction; and methodological characteristics including internal validity score and category of instruction (group versus individual).

At the completion of coding of studies, intra-coder reliability was established. The studies were divided into three groups reflecting a time period when each group was coded, either beginning, middle, or end. Using a random numbers table, two

studies from each time period were selected and coded a second time. An overall reliability percentage of 89% was established for the six studies. Inter-coder reliability was also established between the researcher and a second coder of similar qualifications. The same method was employed as for intra-coder reliability and an overall inter-coder reliability of 85% was obtained.

Effect Size Calculations

Effect size is a standardized measure which allows the researcher to compare the effectiveness of a treatment group to that of a control group (Glass, McGaw, & Smith, 1981). In this study, effect sizes were calculated by weighting of sampling variances. In this statistical approach the central assumption is that "nonsystematic variance of effect sizes is inversely proportional to the sample size of the study on which the estimate is based" (Hedges & Olkin, 1985, p.11). According to Hedges (1981), "...the variance for each estimator [of effect size] is a function of sample size and the true effect size" (p. 125). Thus, studies with small sample sizes have larger variances, are less accurate estimators of IV achievement differences, and have less weight. Prior to combining effect sizes, Hedges (1981) recommended weighting each effect size by the reciprocal of its

variance. Therefore, our effect sizes were calculated for each individual study using the formula:

$$\text{Effect Size} = \frac{\underline{M} \text{ score experimental grp} - \underline{M} \text{ score control grp}}{\text{pooled standard deviation}}$$

The pooled standard deviation is:

$$\sqrt{\frac{[(n_e - 1) * m_e^2 + (n_c - 1) * m_c^2]}{n_e^2 + n_c^2 - 2)}}$$

where $n_e$ and $n_c$ are the number of subjects in the experimental and control groups respectively and $m_e$ and $m_c$ are the mean treatment effects of the experimental and control groups respectively.

To correct for small sample size bias, Hedges (1981) recommends multiplying the effect size by a correction factor, $\underline{c}$:

$\underline{c} = [1 - (3/ 4m - 1)]$ where $\underline{m} = n_e + n_c - 2$, where $\underline{m}$ is the pooled estimate, $n_e$ = number of subjects in the experimental group and $n_c$ = number in control group.

The mean effect size represents the overall treatment effectiveness across studies. As recommended by Hedges and Olkin (1985) each effect size is weighted by using the reciprocal of its variance. Consequently, studies with greater sample size receive more weight. Confidence intervals and the standard deviation for the weighted mean of a group of effect sizes can then be

calculated and interpreted.

To counter the criticism that meta-analysis mixes "apples and oranges" by combining diverse studies, Hedges (1982) proposed a test of homogeneity which tests whether all effect sizes are estimating the same population treatment effect. Should heterogeneity be evidenced, then it may be more effective to conduct multiple meta-analyses rather than combine results in one meta-analysis.

Data Analysis. Data were analyzed using the statistical package, Statistical Analysis System (SAS), version 5.16. For all statistical analyses, a significance of .05 was set a priori. The initial steps in data analysis were to collapse the variable data and calculate an overall average effect size statistic for the studies.

Of the 79 variables which were initially coded, 25 major variables which were representative of the four main categories of variables coded for each study were selected. Overall mean effect size was calculated and a test of homogeneity conducted using procedures suggested by Hedges and Olkin (1985). Subsequently, data were sorted by IV research category: comparative studies versus instructional design studies.

Data were then analyzed to determine relationships among

variables utilizing the Spearman r correlation statistic. Predictor variables were selected which most highly correlated with the criterion variables. For each IV category, the forward selection technique was used to assess the contribution of each independent variable to the model.

Variables which conceptually could account for variation in learning achievement were then selected for a weighted regression procedure. The output from a weighted regression procedure provides information regarding model specification, presence of outlier studies, and identification of significant independent variables accounting for variation in achievement.

## Results and Discussion

### Study Characteristics and Methodological Features

Year of publication. As shown in Table 3, 50% of the total studies (n=32) were published between 1986 and 1988. The number of studies (n=15) published earlier, from 1978 to 1983 approached 25%. The pattern of a low percentage of studies appearing in the late 70s and early 80s followed by a majority of studies published in the mid to late 80s seems to reflect a growing interest and activity in IV research.

Insert Table 3 About Here

Type of publication. The data in Table 3 show that the bulk of studies (n=30) consisted of unpublished doctoral dissertations, masters theses, or government reports. Almost 37% (n=23) were published as journal articles. The remaining studies were ERIC documents, paper presentations, or papers published in conference proceedings.

Overall, mean effect size for each manuscript category was positive. As shown in Table 4, published journal articles reported the higher mean effect size compared to other categories of manuscripts. The lowest average effect size was reported by studies found in ERIC documents, paper presentations, and papers published in conference proceedings. Average effect size for published manuscripts was significantly greater ($p<.05$) than effects for unpublished studies.

Insert Table 4 About Here

Higher effect sizes for published papers are not surprising; more significant effects in published articles have been found in

studies on computer-based instruction (Kulik & Kulik, 1987) and computer-assisted instruction (Hartley, 1977). Hartley suggested that dissertations may be the most unbiased source of evaluative information for computer-based instruction since they contain negative, positive, and neutral findings. Likely explanations for greater effects in journal articles include editorial gatekeeping (significant results more apt to be published), and differences in research experience and resources of journal authors. Evaluators of IV should attempt to examine unpublished as well as published evaluative documents in order to secure the most accurate picture of IV effectiveness.

Research category. The nature of IV research conducted during the 10 year period was examined. Brody (1984) recommended that IV researchers move away from comparative studies and move toward research on and with IV. Tables 3 and 4 present frequency and mean effect size data for two types of IV evaluation research: studies which compared IV to a traditional form of instruction such as lecture-demonstration, and studies which investigated how to increase the effectiveness of IV through manipulation of design features such as learner control of sequencing.

Conceptually, the nature of the studies within each IV research category differ. The major difference centers around the

comparison group. "Horserace" studies use a traditional, non-interactive video comparison group. Instructional design studies utilize IV as a comparison.

The majority of studies (n=50) were comparative evaluations. This group of studies averaged a greater achievement effect than instructional design studies. However, the mean difference in effects was not significant ($p>.05$). Since the number of effects for instructional design studies was small, comparisons among the categories must be interpreted cautiously.

Supplement versus replacement for instruction. The majority of studies (n=38) utilized IV instruction as a replacement for the usual instruction (see Table 3). Almost one third of the studies (n=20) were interested in achievement effects when IV was used as a supplement to instruction. The remainder of the studies utilized IV as both a replacement for and supplement to instruction or did not document how IV was used. Compared to use of IV as a replacement for instruction, studies employing IV for supplementing instruction averaged significantly ($p<.05$) higher achievement effects. When comparative or "horserace" studies were examined separately, mean achievement for IV as a supplement was significantly greater ($p<.05$) than IV which replaced traditional

forms of instruction. Similar findings were reported for computer-assisted instruction in mathematics (Burns & Bozeman, 1981; Hartley, 1977).

The findings in the current study imply that learners can benefit from IV when it both replaces and augments usual forms of instruction. Specific design features of IV such as ability to present real-life situations, motion, and color may partially explain the findings. Obtaining several of the evaluative reports in this meta-analysis may provide the reader with insight into the details of specific instructional design aspects which contributed to achievement effects.

Affiliation of research. Research studies from the educational sector (n=38) accounted for almost two thirds of the total sample (see Table 3). The smallest number(n=10) were from private industry. Bosco (1986) noted that although private industry and the military were the highest producers of IV, he could gain access to only a small number of evaluations from private industry. He cited the proprietary nature of reports or the lack of systematic evaluations as possible explanations for the low number of reports from industry.

Inability to review reports from private industry is problematic since the data may provide a clearer understanding of

how effectively designed IV programs contribute to learning. In this study the majority of reports secured from private industry were anecdotal in nature or did not include minimal data to calculate effect size. In many instances, the reports described an IV product and reported user reactions to it. Because of the nature of these studies, they were excluded from the meta-analysis.

Internal validity score. A total score for internal validity was assigned to each study. Over three quarters of the studies ($n$=48) were rated as high. These studies were judged to have attempted to control a large majority of the following threats to internal validity: history, maturation, testing, instrumentation, statistical regression, selection bias, experimental validity, and expectancy (Cook & Campbell, 1979). An additional 19% of the studies were ranked as moderate while the remainder were considered as low or controlling for only a few threats to internal validity.

Highest observed mean achievement effects were found for studies with high internal validity scores (see Table 4). However, the mean effect sizes in high internally valid studies were not significantly greater ($p>.05$) than studies with moderate or low internal validity.

In a meta-analysis of computer-assisted instruction, Hartley (1977) reported greater effects in weaker research designs such as those lacking a control group or nonrandom assignment of subjects to treatments. Hartley advised that results should be interpreted cautiously due to small sample sizes. Kulik and colleagues (1980) found little relationship between type of research design features and learning outcomes.

Same teacher effect. The variable of having the same teacher for both treatments has been addressed in traditional reviews and other meta-analyses in instructional technology. For instance, Kulik et al. (1980) reported that control for instructor effects was the single variable which best predicted study outcomes. They found the magnitude of effect differences was less in same instructor studies compared to studies employing different teachers. It was suggested that involving teachers in innovative approaches to instruction such as computer-based instruction may improve the quality of their teaching in conventional teaching assignments.

Clark (1986) reanalyzed a portion of Kulik and colleagues data, and reported a much smaller effect size for same teacher studies. He concluded that instructional method and curriculum

content were not controlled in all studies which employed the same teacher for both experimental and control groups.

As shown in Table 4, the average effect in studies using the same teacher in both the experimental and control groups was approximately equal to mean effect in studies using different teachers ($p>.05$). Almost all of the studies which investigated design features used the same instructor in all treatments. However this was not the case for comparative studies.

Group versus individual instruction. A majority of studies ($n=49$) focused on instruction for individual learners (see Table 3). A smaller number of studies employed IV for group instruction. Mean achievement effect for group instruction was slightly greater than in individual instruction (see Table 4) but the difference was not significant ($p>.05$). Results should be interpreted with caution due to the small number of effect sizes contributing to mean effect for group instruction. Also, characteristics of individual learners such as learning style, attitudes, values and other personality traits may produce considerable variability in scores and result in an overall lower achievement effect.

Generally, it appears that IV is useful for both individual and group instruction. This concurs with viewpoints of Milheim

and Evans (1987) who postulated that students benefit from the interaction with others in group instruction. Hofmeister et al. (1986) reminded researchers and educators that "the technologically based individual learning station must not be viewed as the ultimate delivery system for the public school" (p. 37). Group-paced systems can be as effective as self-paced systems.

Format of IV. More than half of the studies (n=37) utilized a videodisc as the vehicle for delivering IV instruction. It was not surprising to find that achievement effects via videodisc were not significantly different ($p>.05$) from effects with videotape. Clark (1983) has emphatically stated that media are "...mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition" (p.445). Hence, instructional methodologies in IV lessons may promote positive achievement effects, but learner characteristics, instructional design features, and other unknown factors may be as much or more responsible for the positive learning outcomes in these studies.

Interactivity levels. Over 80% of the studies were Level 3 systems which employed a videodisc/tape player and a microcomputer. No studies employed Level 2 systems (see Table 3).

The findings for levels of interactivity reflect the current predominant use of Level 3 systems for education and training. Differences in mean achievement effects among levels were not significant ($p>.05$).

Task for achievement measure. The nature of the learning outcome was coded for each study. Categories of learning outcomes described by Gagne (1977) include: (a) verbal information such as names and labels, (b) intellectual skills including concepts, rules, and problem solving, (c) cognitive strategies, (d) motor skills, and (e) attitudes. As shown in Table 3, a majority of the studies ($n=25$) required the learner to recall facts, apply rules/principles, and solve problems. Thus, most of the studies required the learner to use higher order cognitive skills beyond simple recall. No significant difference in mean effect ($p>.05$) was found due to type of achievement measure.

Type of application. Almost 50% ($n=29$) of the studies used a combination of drill/practice, tutorial, simulation, and motor skills training, which reflects the ability of IV designers to accommodate different types of learning applications. The mean differences between types of learning application were not significant ($p>.05$).

Content of instruction. Percentages for categories of instructional content are listed in Table 3. Content which involved a combination of cognitive skills (n=18) had significantly ($p<.05$) higher achievement effects for all categories of content except rule/principle learning. This trend may reflect the ability of IV instruction to represent content in a variety of ways and influence achievement outcomes. Gagnon (1986) proposed that if media utilize different cognitive skills then measurable differences in learning may be expected. For these studies, IV instruction may have required a different yet higher level of processing compared to conventional instruction.

Type of learner control of sequence. A major portion of studies (26.2%) utilized an IV program which was designed to provide the learner with control of sequence of instruction (see Table 3). The average effect size for IV in these studies was positive but smaller than program or guided control studies.

A small percentage (9.8%) of studies used IV programs which were designed with guided control of instruction. The average effect for these studies was highly positive. In program controlled lessons, learners generally have little or no control over the instructional path. Mean outcomes for such studies were highest and significantly different ($p<.05$) from learner

controlled studies.

Most frequently (n=18) IV instruction included a combination of control strategies. The mean effect size for this group of studies was low and positive. Almost one fifth of studies (n=12) did not identify the nature of control of sequencing. For these studies, the mean effect size was positive and significantly lower ($p<.05$) than learner controlled or program controlled studies.

In order to interpret the results for control for sequence, a variety of factors need to be explored. Hannafin (1984) has presented many of these factors. Learner characteristics such as age, ability, and prior experience must be considered. The nature of the learning task including type of information being processed is an additional important variable which may account for differences in effects among control options. Designers would do well to consider a multitude of factors in the learning situation when making decisions regarding learner control in IV lessons.

Control of review and practice. In this sample of studies as shown in Table 3, almost half (48.3%) provided the learner with a combination of control options (learner, guided, and program). An additional 30% of studies were equally divided between either learner, guided, or program control.

Achievement effects as shown in Table 4, were highest for

studies which employed IV designed with guided control of review and practice. However, this is based on a small subsample of studies (n=5). Learner controlled IV programs demonstrated the lowest mean effect size which was significantly lower ($p<.05$) than all other control categories. The IV programs which utilized either a combination of control types or program control of instruction were almost equally positive in mean achievement effect.

In view of the small sample sizes, the findings must be interpreted cautiously. It appears that learners benefited more from guidance or suggestions on what to review after incorrectly responding to embedded questions.

## Effect Size and Model Specification

In the following sections results from tests of homogeneity of effect size and model specification, correlations of effect sizes with independent variables and the results of regression analyses are discussed.

### Overall Mean Effect Size

For 63 studies, there were 100 achievement outcomes or effect sizes. The overall weighted mean effect was .502 with a standard deviation of 0.966. Fifty-one effects were significantly positive and five were significantly negative. The 95% confidence

limits around the mean effect size were +.310 and +.694. The 95% confidence interval does not include zero, indicating that the mean effect size of .502 is not likely due to chance.

A mean overall achievement effect of .502 across a broad range of interdisciplinary studies constitutes a conventional measure of practical significance (Wolf, 1986). The magnitude of the effect and the positive direction indicate that achievement outcomes were greater for IV than the control group. An effect of .502 can further be interpreted to mean that the average person receiving IV instruction would have an achievement score greater than 69.2% of the individuals in the control group.

Achievement effects for computer-assisted instruction (CAI) approach those of IV. Hartley (1977) reported an overall mean effect size of .40 for CAI. Kulik et al., (1980) examined 54 studies of computer-based teaching and reported an overall achievement effect of .25 for college students and .32 for secondary students. Burns and Bozeman (1981) reported higher mean effects in a review of 40 CAI studies: .339 for drill/practice format and .445 for tutorials. Clark (1986) and Niemiec and Walberg (1987) found comparable effect sizes for CAI studies (.49 and .42, respectively). Thus, the average overall effect for IV in the current study was slightly higher than those reported for

CAI. Video capabilities of IV, such as ability to depict real-life situations, may account in part for differences in effects between CAI and IV. However, a comparison of IV with CAI was not a primary focus of the meta-analysis.

Test of Homogeneity of Effect Sizes

Hedges (1982) introduced a test of homogeneity (H) to determine if all effect sizes were estimating the same population treatment effect. H is the weighted sum of squared deviations of effect sizes from the overall weighted mean, and it is tested as a chi square distribution with degrees of freedom equal to the number of effect sizes minus one (Thomas & French, 1986).

Our computed chi square value was significantly greater than the table value $X^2 = 154.89$ (100, $N = 63$) $p<.05$, which indicated that effect sizes for the studies were heterogeneous. It was hypothesized a priori that potential sources of heterogeneity would be the wide range of instructional groups being compared to interactive video, different achievement outcomes, and diverse learner characteristics.

Following the recommendations of Hedges and Olkin (1985), outlier studies were examined. Regression residuals were standardized to z scores. Any observation with a z score of 2 or greater was considered an outlier, since these observations fall

outside the 95% distribution (Thomas & French, 1986). Six outliers were identified.

Examination of the six outlier studies revealed that three dealt with children of special populations (mentally handicapped, learning disabled, and deaf children). Sometimes outliers indicate that other variables, such as IQ should be added to the model (Thomas & French, 1986). In the other three outlier studies, the measurement of achievement may have produced the deviant results. One used an audio test, one used a physical skill test and one a self-report of behavior.

A weighted regression procedure was re-run with outliers deleted, and the results indicated that heterogeneity of effects continued to exist. As shown in Table 4, when the outliers were removed, the overall mean effect increased to .530 with a standard deviation of 0.801. Sustained heterogeneity of effects suggests that it may be more effective to conduct multiple meta-analyses rather than combine results in one meta-analysis (Hedges & Olkin, 1985).

Model Specification

Data were separated into two classes: comparative studies and instructional design studies. Attempts were made to find an exemplary model for each category of IV study. Spearman r

correlations were computed for 28 independent variables and the dependent variable, effect size. Correlation coefficients were generally found to be low. Subsequently, 12 independent variables were identified on the strength of their association with effect size. The 12 variables were: learner control of sequence, presence of embedded questions, learner control of review and practice, format of IV (videotape or disc), use of IV as supplement or replacement for instruction, interactivity level (1 to 4), content of instruction, instructional application of IV (tutorial, etc.), internal validity score, review after incorrectly responding to embedded questions, evidence of same teacher effect, and type of task for the achievement measure (see Table 5).

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Insert Table 5 about here

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The 12 independent variables were effect coded and entered into a forward selection regression procedure. For instructional design studies (Table 6), three variables emerged as most important to effect size: instructional content requiring problem-solving content (51% of variance), content combining facts, psychomotor skills, concepts, rules/principles, and

problems (10.6%), and guided control of sequence (8.2% of variance).

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Insert Table 6 about here

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For comparative studies, the selected variables contributed relatively little in explaining the effect size variance. As shown in Table 6, the variables were: learner control of review and practice (17.4% of variance), content of instruction (both problem solving at 8.5% of the variance and a combination of types of content, 10.3% of variance), and guided control of sequence (3.4% of variance).

For instructional design studies, the test of regression was significant, $X^2 = 20.67$ (3, $N = 17$), $p<.05$. This indicated that effect sizes about the regression line were homogeneous. The test for model specification was also significant, $X^2 = 33.86$ (13, $N = 17$), $p<.05$. This finding indicated that effect sizes from these studies were not consistent with the data analysis model (Hedges & Olkin, 1985, p.173). Other variables unknown to the experiment provided a better explanation of effect size. A similar occurrence was discovered for comparative studies. The test of regression and model specification were both significant,

indicating that effect sizes were homogeneous but the independent variables did not explain achievement effect. This was not too surprising, since there are numerous variables that contribute to achievement.

An essential ingredient in any learning situation is the learner. An understanding of the diverse characteristics of learners may aid in explaining learning outcomes. The interaction effects of learner traits such as intelligence quotient, prior experience, and cognitive style with IV features remains to be investigated. Data for two learner characteristics, gender and age, were included, but these variables were omitted in over 75% of the studies.

Another element to be considered in understanding IV achievement differences is within the instructional design of the IV. Different instructional features or a combination of features may account for differences in achievement. A closer examination of studies within this category of studies is warranted. The complex nature of learning necessitates sorting through the interconnections between learner characteristics, instructional design features of learning materials, instructional content, the learning environment and instructional methods employed in IV instruction.

## Conclusions

Overall, the results of the meta-analysis of 63 studies on IV showed a positive effect size (.530, corrected for outliers) indicating that IV is an effective form of instruction. The bulk of the studies have been done within the last 10 years, which reflects the growing interest in IV research. The importance of the teacher was implicated in this meta-analysis. Differences in program effectiveness favoring group instruction may be explained by factors such as decisions made by the teacher relative to amount of practice, the extent and kind of feedback and the nature of remediation procedures. Moreover, program-controlled IV appears to be more effective than learner-controlled IV. This may be further evidence that IV is best accomplished when it is guided and structured as opposed to being entirely under the control of the learner.

Our failure to account for much of the variance in the models by independent variables analyzed in the study indicates that cognitive achievement from IV is influenced by a myriad of variables that are difficult or impossible to account for in a single meta-analysis. Variables such as the nature of instructional content, environmental factors, instructional methods, features of the learning materials, and certainly the

characteristics of the learner undoubtedly influence achievement to varying degrees. This information is rarely provided in sufficient detail to be coded and analyzed. Generalization is almost impossible due to the complex interrelationships among compatible variables and instructional conditions. Suffice to say at this point, IV is an effective instructional method, at least as a supplement to regular instruction. More definitive analysis of its efficacy must await further investigations which examine the interaction of learner differences and methodology.

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Table 1

Levels of Interactivity*

| System Level | Description |
|---|---|
| 0 | Utilizes a linear videodisc player. Limited interactivity. Home entertainment and similar applications as videotape players and movie projectors. |
| 1 | Level 0 system plus quick frame access, freeze frame, scanning functions, two audio channels, chapter and picture stops. |
| 2 | Level 1 functions plus an internal microprocessor. Combinations of functions are possible by input through player's control panel. |
| 3 | A Level 1 or 2 player linked to a microcomputer. Read and write functions of the computer provide added intelligence to the system. Both computer and video-generated material can be displayed. |
| 4 | Level 3 system powered by additional microcomputer software such as a type of artificial intelligence software. |

*(Cited in Hofmeister et al., 1986)

Table 2

List of Studies Included in the Meta-Analysis (N = 63)

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Table 3

Frequency Data For Selected Variables (N = 63 Studies)

| Study Variable | N | % |
|---|---|---|
| Year of Publication | | |
| 1978-1980 | 3 | 4.8 |
| 1981-1983 | 12 | 19.0 |
| 1984-1985 | 16 | 25.4 |
| 1986-87 | 27 | 42.9 |
| 1988 | 5 | 7.9 |
| Type of Publication | | |
| Dissertations, Theses, Govt. Rpts | 30 | 47.6 |
| Published Journal Articles | 23 | 36.5 |
| ERIC Documents, Papers, Proceedings | 10 | 16.9 |
| IV Research Category | | |
| Instructional Design Studies | 13 | 20.6 |
| Comparative Studies | 50 | 79.4 |
| Implementation of IV | | |
| Replacement for Usual Instruction | 38 | 60.3 |
| Supplement to Instruction | 20 | 31.7 |
| Both or Use Not Specified | 5 | 8.0 |

(table continues)

Table 3

Frequency Data For Selected Variables (N = 63 Studies)

| Study Variable | N | % |
|---|---|---|
| Affiliation of Research | | |
| Education | 38 | 60.3 |
| Military | 15 | 23.8 |
| Private Industry | 10 | 15.9 |
| Internal Validity Score | | |
| Low Control | 3 | 4.8 |
| Moderate Control | 12 | 19.0 |
| High Control | 48 | 76.2 |
| Effect of Instructor | | |
| Different Instructors | 23 | 36.5 |
| Same Instructor | 24 | 38.1 |
| Cannot Determine | 9 | 14.3 |
| Not applicable | 7 | 11.1 |
| Types of Instruction | | |
| Group | | 11.5 |
| Individual | 49 | 77.8 |
| Both | 1 | 1.6 |
| Not specified | 2 | 3.2 |

(table continues)

Table 3

Frequency Data For Selected Variables (N = 63 Studies)

| Study Variable | N | % |
|---|---|---|
| Format of IV | | |
| Videodisc | 37 | 58.7 |
| Videodisc | 26 | 41.3 |
| Levels of Interactivity | | |
| Level 1 | 5 | 8.1 |
| Level 2 | 0 | 0 |
| Level 3 | 50 | 80.6 |
| Level 4 | 1 | 1.6 |
| Level 3 to 4 | 5 | 8.1 |
| Cannot Determine | 1 | 1.6 |
| Task of the Achievement Measure | | |
| Apply rules/principles and/or solve problems | 3 | 4.8 |
| Recall verbal info, facts, concepts | 16 | 25.4 |
| Recall facts, apply rules/principles and solve problems | 25 | 39.7 |
| Cannot determine | 6 | 9.5 |
| Perform a skill | 4 | 6.3 |
| Recall, application, & skill perform. | 9 | 14.3 |

(table continues)

Table 3

| Frequency Variable | N | % |
|---|---|---|
| Type of Application | | |
| Drill and Practice | 1 | 1.6 |
| Tutorial | 17 | 27.0 |
| Simulation or Problem-Solving | 7 | 11.1 |
| Motor Skills Training | 2 | 3.2 |
| Combination of All | 29 | 46.0 |
| Intelligent System | 2 | 3.2 |
| Cannot Determine | 5 | 7.9 |
| Major Content of Instruction | | |
| Facts, Concepts, Rules, Problems | 18 | 28.6 |
| Concepts | 11 | 17.5 |
| Skill Procedures | 2 | 3.2 |

Table 4.

Effect Size As A Function of Study Variables

| Study Variable | Number Of Effects | Mean Effect |
|---|---|---|
| Type of Publication | | |
| Unpublished | | |
| Dissertations, Theses, Govt. Reports | 41 | .4008* |
| ERIC Documents, Papers, Proceedings | 19 | 1.1339 |
| Published Journal Articles | 40 | .7404* |
| IV Research Category | | |
| Comparative Studies | 82 | .5851 |
| Instructional Design Studies | 18 | .1251 |
| Implementation of IV | | |
| Replacement for Instruction | 64 | .3573* |
| Supplement to Instruction | 29 | .7715* |
| Both or cannot determine | 7 | - |
| Internal Validity Score | | |
| Low | 4 | .1341 |
| Moderate | 22 | .1709 |
| High | 74 | .6207 |
| Control for Teacher Effects | | |
| Different Teacher | 34 | .3442 |
| Same Teacher | 35 | .3582 |
| Unspecified | 31 | - |

(table continues)

Table 4

Effect Size As A Function of Study Variables

| Study Variable | Number Of Effects | Mean Effect |
|---|---|---|
| Control for Teacher Effects | | |
| Comparative Studies | | |
| Different Teacher | 30 | .3873 |
| Same Teacher | 19 | .5551 |
| Unspecified and Missing Values | 33 | - |
| Type of Instruction | | |
| Group | 15 | .6697 |
| Individual | 80 | .4456 |
| Combination or Unspecified | 5 | - |
| Format of IV | | |
| Videodisc | 67 | .9868 |
| Videotape | 33 | .9279 |
| Levels of Interactivity | | |
| Level 1 | 11 | .2519 |
| Level 3 | 73 | .5479 |
| Level 4 | 8 | .7569 |
| Level 3 to 4 | 6 | .0409 |
| Unspecified or Missing Value | 2 | - |
| Type of Instructional Content | | |
| Concepts | 20 | .7130* |
| Rules and Principles | 7 | 1.0870 |
| All Types of Content | 34 | .3875* |
| Combination of All Cognitive Skills | 27 | .8403* |

(table continues)

Table 4.

Effect Size As A Function of Study Variables

| Study Variable | Number Of Effects | Mean Effect |
|---|---|---|
| Type of Application | | |
| Drill and Practice | 2 | .0443 |
| Tutoring | 29 | .6140 |
| Simulation | 7 | .6725 |
| Combination of drill, tutoring, & simulation | 19 | 1.039 |
| Combination of All Skills | 22 | .2620 |
| Motor Skills Training | 4 | -1.029 |
| Cannot Determine | 17 | - |
| Type of Control for Sequence of Instruction | | |
| Program | 12 | 1.1960 * ** |
| Learner | 29 | .4399 * ** |
| Guided | 8 | 1.0930 |
| Unspecified | 16 | .2268** |
| Combination | 32 | .3310 |
| Missing Values | 3 | - |
| Review and Practice After Incorrect Responses to Embedded Questions | | |
| Program | 8 | .5962* |
| Learner | 13 | -.3760* |
| Guided | 7 | 1.1754* |
| Unspecified | 17 | .4519* |
| Combination | 48 | .6812* |
| Missing Values | 7 | - |

(table continues)

Table 4.

Effect Size As A Function of Study Variables

| Study Variable | Number Of Effects | Mean Effect |
|---|---|---|
| Mean Overall Effect | 100 | .502 |
| | | (.966 S.D.) |
| Mean Overall Effect # | 89 | .530 |
| | | (.801 S.D.) |

Note: *Values are significantly different at the .05 level.
**Values are significantly different at the .01 level.
#Values reflect exclusion of effects from outlier studies.

Table 5
Correlations of Independent Variables with Effect Size

| Variable | Correlation with Effect Size |
|---|---|
| Year of Publication | .088 |
| Type of Manuscript | .031 |
| IV Research Category | .179 |
| Supplement or Replacement for Instruction | .163 |
| Category of Instruction (Group vs Individual) | -.048 |
| Type of Input Device | -.070 |
| Presence of Embedded Questions | -.009 |
| Control Practice/Review After Incorrect Responses | .153 |
| Locus of Control for Sequence of Instruction | -.138 |
| Level of Interactivity of IV System | -.038 |
| Affiliation of Research | -.044 |
| Task For the Achievement Measure | -.130 |
| Format of IV (Videodisc versus Videotape) | .085 |
| Evidence of Same Teacher Effect | .215 |
| Type of Content | .150 |
| Internal Validity Score | .294 |
| Production of IV materials | -.148 |
| Location of Embedded Questions | -.009 |
| Branching after Correct Responses to Questions | -.140 |
| Educational Level of Subjects | -.149 |
| Gender of Subjects | -.056 |
| Type of Application | -.123 |

Table 6

Forward Selection Procedure By Type of Research Study

| Variable | Partial $R^2$ | Cumulative $R^2$ | F Value | p |
|---|---|---|---|---|
| **Instructional Design Studies** | | | | |
| problem solving | .511 | .511 | 15.705 | .001 |
| all types of content | .106 | .617 | 3.866 | .069 |
| guided control of sequence | .082 | .792 | 4.325 | .062 |
| **Comparative Studies** | | | | |
| learner control of review & practice | .174 | .174 | 15.546 | .0002 |
| all types of content | .103 | .276 | 10.342 | .002 |
| problem solving | .085 | .361 | 9.573 | .003 |
| guided control of sequence | .034 | .432 | 4.204 | .044 |